

## CLAIMS

*Sub A7*

1. A bump forming apparatus for charge appearance semiconductor substrates which is equipped with a bump forming head (120) for forming bumps onto electrodes of a circuit on the charge appearance semiconductor substrate (201, 202) which generates electric charge in consequence of a temperature change in a state while heated to a bump bonding temperature necessary for forming the bumps,

10 said bump forming apparatus comprising:

15 a heating and cooling apparatus (110, 160, 170) for eliminating electric charge generated to the substrate as a result of a decrease in temperature in cooling the substrate after bumps are bonded to the heated substrate;

20 and

25 a controller (180) for executing a decrease in temperature control for cooling the substrate after the bonding to the heating and cooling apparatus.

2. The bump forming apparatus for charge appearance semiconductor substrates according to claim 1, wherein, when executing the cooling, the heating and cooling apparatus comes in contact with a rear face (202b) opposite to a front face (202a) as a circuit-formed face of the charge appearance semiconductor substrate so as to eliminate charge generated to the substrate because of the

decrease in temperature in the cooling.

3. The bump forming apparatus for charge appearance semiconductor substrates according to claim 2, wherein the heating and cooling apparatus preheats the substrate to a 5 vicinity of the bump bonding temperature before heating the substrate to the bump bonding temperature, and further eliminates charge generated to the substrate because of a temperature rise by the preheating through contact with the rear face of the substrate,

10 the controller executes a temperature rise control for the preheating operation to the heating and cooling apparatus.

4. The bump forming apparatus for charge appearance semiconductor substrates according to claim 3, wherein the 15 heating and cooling apparatus comprises a bump bonding stage (110) for heating the substrate to the bump bonding temperature, and a cooling device (170) for cooling the substrate in accordance with the decrease in temperature control by the controller.

5. The bump forming apparatus for charge appearance semiconductor substrates according to claim 3, wherein the heating and cooling device comprises a bump bonding stage (110) for heating the substrate to the bump bonding temperature, and a preheat device (160) for preheating the 25 substrate in accordance with the temperature rise control

by the controller.

6. The bump forming apparatus for charge appearance semiconductor substrates according to claim 4, wherein the cooling device includes a heat diffuser member (163, 173) 5 which comes in contact with the rear face of the substrate, a heating part (161, 171) detachable to the heat diffuser member for raising the heat diffuser member in temperature, and a separator (1601, 1701) for separating the heat diffuser member and the heating part so as to promote 10 cooling of the heat diffuser member.

7. The bump forming apparatus for charge appearance semiconductor substrates according to claim 5, wherein the preheat device includes a heat diffuser member (163, 173) which comes in contact with the rear face of the substrate, 15 a heating part (161, 171) which comes in contact with the heat diffuser member so as to raise the heat diffuser member in temperature, and a separator (1601, 1701) for separating the heat diffuser member and the heating part so as to promote cooling of the heat diffuser member.

20 8. The bump forming apparatus for charge appearance semiconductor substrates according to claim 2, which further comprises a gas supply device (115, 1611, 1711) for supplying a gas to the substrate placed to the heating and cooling apparatus,

25 wherein the controller executes a warpage

correction control for correcting a warpage generated to the substrate placed to the heating and cooling apparatus to either the gas supply device, or the heating and cooling apparatus.

5 9. The bump forming apparatus for charge appearance semiconductor substrates according to claim 8, wherein the controller executes a blowing control for charge removal for eliminating charge generated to the substrate placed to the heating and cooling apparatus to the gas supply device.

10. The bump forming apparatus for charge appearance semiconductor substrates according to claim 2, which further comprises a contact member (14100, 14161) for charge removal which comes in contact with the front face of the substrate to remove an amount of charge generated to 15 the front face.

11. The bump forming apparatus for charge appearance semiconductor substrates according to claim 2, which further comprises an ion generator (190) for generating ions for neutralizing charge accumulated to the substrate.

20 12. The bump forming apparatus for charge appearance semiconductor substrates according to claim 11, which further comprises a wafer holding part (1411, 1421) with holding hooks (1417) for holding the substrate by the holding hooks and transferring the substrate to the heating and cooling apparatus, wherein the wafer holding part and

SEARCHED INDEXED  
SERIALIZED FILED  
2020-07-07

2020-07-07

the holding hooks are coated with an insulating material at a portion (14172, 14174) where the ions generated from the ion generator act.

13. The bump forming apparatus for charge appearance 5 semiconductor substrates according to claim 2, wherein the heating and cooling apparatus is metal plated (261) at a portion in contact with the rear face of the substrate for improving a heat conductivity between the heating and cooling apparatus and the substrate and removing charge of 10 the substrate.

14. A method for removing charge of charge appearance semiconductor substrates which generate electric charge in consequence of a temperature change thereof, which comprises:

15 forming bumps to electrodes of a circuit on the substrate with the substrate heated to a bump bonding temperature necessary for forming the bumps,

when the substrate is cooled after forming bumps,  
and

20 eliminating electric charge which is generated to the substrate as a result of a decrease in temperature in cooling the substrate through a load member on which the substrate is placed.

15. The charge removal method for charge appearance 25 semiconductor substrates according to claim 14, further

comprising blowing a gas to the substrate loaded on the load member for eliminating charge generated to the substrate.

16. The charge removal method for charge appearance 5 semiconductor substrates according to claim 14, further comprising acting ions to the substrate for neutralizing charge accumulated to the substrate.

17. The charge removal method for charge appearance 10 semiconductor substrates according to claim 14, further comprising:

eliminating charge generated to a circuit-formed face of the substrate by bringing a contact member (14100) for charge removal into contact with the circuit-formed face of the substrate.

15 18. A charge removing unit for charge appearance semiconductor substrates, which comprises:

a heating and cooling apparatus (110, 160, 170) which comes in contact with a rear face (202b) opposite to a front face (202a) as a circuit-formed face of the charge 20 appearance semiconductor substrate which generates electric charge in consequence of a temperature change, thereby removing electric charge generated to the substrate as a result of a decrease in temperature in cooling the substrate after heating the substrate; and

25 a controller (180) for executing a decrease in

temperature control for cooling the substrate to the heating and cooling apparatus.

19. A charge appearance semiconductor substrate which comprises:

5 a region for charge removal (14165) which is formed to a front face (202a) as a circuit-formed face of the charge appearance semiconductor substrate (201, 202) which generates electric charge in consequence of a temperature change, and which is formed of a conductor for 10 eliminating electric charge generated to the substrate; and dicing lines (212), connected to the region for charge removal, for dicing circuit-formed parts (211) formed to the front face from the substrate.

20. A method for removing charge of charge appearance 15 semiconductor substrates, which comprises:

bringing a charge appearance semiconductor substrate defined in claim 19 into contact with a contact member (14100, 14161) for charge removal defined in claim 10; and

20 eliminating electric charge generated to the substrate.

21. A charge appearance semiconductor substrate, which has an amount of electric charge of not larger than  $\pm 200V$  because of eliminating electric charge generated to 25 the charge appearance semiconductor substrate (201, 202)

*Sub A57*

which generates electric charge in consequence of a temperature change.

22. The charge appearance semiconductor substrate according to claim 21, which has charge eliminated by the 5 charge removal method according to any one of claims 14-17.

23. The charge appearance semiconductor substrate according to claim 21, which has charge eliminated by the charge removing apparatus for charge appearance semiconductor substrates according to claim 18.

10 24. The charge appearance semiconductor substrate according to claim 21, which has charge eliminated by the charge removal method according to claim 20.

25. The bump forming apparatus for charge appearance semiconductor substrates according to claim 1, wherein the 15 decrease in temperature control by the controller is a control for eliminating charge generated to the charge appearance semiconductor substrate as a result of the decrease in temperature in the cooling,

while the heating and cooling apparatus heats the 20 substrate to the bump bonding temperature in a noncontact state to the substrate and cools the substrate in the noncontact state in accordance with the decrease in temperature control by the controller after the bonding.

26. The bump forming apparatus for charge appearance 25 semiconductor substrates according to claim 25, wherein the

decrease in temperature control is executed to repeat alternately a decrease in temperature, and a temperature rise with a temperature width smaller than a decrease in temperature width of the decrease in temperature.

5 27. The bump forming apparatus for charge appearance semiconductor substrates according to claim 25, wherein the heating of the substrate at the heating and cooling apparatus to the bump bonding temperature includes preheating operation for preliminarily heating the  
10 substrate to a vicinity of the bump bonding temperature, the controller further executes a temperature rise control for removing charge generated to the charge appearance semiconductor substrate as a result of a temperature rise in the preheating to the heating and  
15 cooling apparatus.

28. The bump forming apparatus for charge appearance semiconductor substrates according to claim 27, wherein the temperature rise control is executed to repeat alternately a temperature rise, and a decrease in temperature with a  
20 temperature width smaller than a raise temperature width of the temperature rise.

29. The bump forming apparatus for charge appearance semiconductor substrates according to claim 25, wherein the heating and cooling apparatus has a bump bonding stage  
25 (110) for heating the substrate to the bump bonding

*Sub A6*

temperature and a cooling device (170) for cooling the substrate in accordance with the decrease in temperature control by the controller.

30. The bump forming apparatus for charge appearance semiconductor substrates according to claim 27, wherein the heating and cooling apparatus has a bump bonding stage (110) for heating the substrate to the bump bonding temperature and a preheat device (160) for preheating the substrate in accordance with the temperature rise control by the controller.

31. The bump forming apparatus for charge appearance semiconductor substrates according to claim 29, wherein an ion generator (190) for generating ions to neutralize charge of the substrate and acting the ions to the substrate is arranged opposite to the substrate placed to the cooling device.

32. The bump forming apparatus for charge appearance semiconductor substrates according to claim 31, wherein the heating and cooling apparatus includes the bump bonding stage (110) for heating the substrate to the bump bonding temperature and a preheat device (160) for preheating the substrate to a vicinity of the bump bonding temperature in a noncontact state to the substrate before heating the substrate to the bump bonding temperature, said preheat device being subjected to a temperature rise control by the

controller for removing charge generated to the substrate as a result of the temperature rise in the preheating, with the ion generator arranged opposite to the substrate disposed to the preheat device.

5 33. The bump forming apparatus for charge appearance semiconductor substrates according to claim 31, which further has a wafer holding part (1411, 1421) with holding hooks (1417) for holding the substrate, thereby holding and transferring the substrate by the holding hooks to the 10 heating and cooling apparatus, wherein the wafer holding part and the holding hooks are coated with an insulating material at a portion where the ions generated from the ion generator act.

15 34. The bump forming apparatus for charge appearance semiconductor substrates according to claim 29, wherein the cooling device has a heat diffuser member (173) which is arranged opposite to the substrate and has a far infrared radiation paint applied to a face opposite to the substrate.

20 35. The bump forming apparatus for charge appearance semiconductor substrates according to claim 30, wherein the preheat device has a heat diffuser member (163) which is arranged opposite to the substrate and has a far infrared radiation paint applied to a face opposite to the substrate.

25 36. The bump forming apparatus for charge appearance semiconductor substrates according to claim 29, which

Sub A7

further includes a warpage correction device (115) connected to the bump bonding stage for correcting a warpage of the substrate loaded to the bump bonding stage.

37. The bump forming apparatus for charge appearance  
5 semiconductor substrates according to claim 29, wherein the controller executes to the bump bonding stage a temperature control for warpage correction for correcting the warpage of the substrate loaded to the bump bonding stage.

10 38. The bump forming apparatus for charge appearance semiconductor substrates according to claim 29, which further has a gas supply device (115) connected to the bump bonding stage for supplying a gas to eliminate charge charged to the substrate loaded to the bump bonding stage, wherein the controller further executes a gas supply  
15 control for charge removal to the gas supply device.

39. The bump forming apparatus for charge appearance semiconductor substrates according to claim 25, which further includes a contact member for charge removal (14100, 14107, 14113, 14116, 14120, 14121, 14122, 14161) which  
20 comes in contact with a front face (202a) as a circuit-formed face of the substrate so as to eliminate an amount of charge generated to the front face of the substrate.

40. A method for removing charge of charge appearance semiconductor substrates which is carried out by a bump forming apparatus, the method comprising:  
25

forming bumps to electrodes formed in a circuit on the substrate which generates electric charge in consequence of a temperature change with the substrate heated to a bump bonding temperature necessary for forming 5 the bumps; and

after the bump-forming, when the substrate is cooled with use of a cooling device (170) arranged in a non-contact state to the substrate for heating the substrate thereby adjusting a decrease in temperature of 10 the substrate, executing a decrease in temperature control for eliminating electric charge generated as a result of the decrease in temperature in cooling the substrate to the cooling device.

41. The charge removal method for charge appearance 15 semiconductor substrates according to claim 40, wherein the decrease in temperature control alternately repeats a decrease in temperature, and a temperature rise by a temperature width smaller than a decrease in temperature width of the decrease in temperature.

42. A charge removing unit for charge appearance semiconductor substrates, which comprises:

a controller (180) for executing a decrease in temperature control to eliminate electric charge generated as a result of a decrease in temperature in cooling after 25 heating the charge appearance semiconductor substrate which

SEARCHED INDEXED  
SERIALIZED FILED

Sub A87

generates electric charge in consequence of a temperature change; and

a heating and cooling apparatus (110, 160, 170) for heating the substrate in a non-contact state to the 5 substrate and cooling the substrate in accordance with the decrease in temperature control by the controller after the cooling.

43. A charge appearance semiconductor substrate with electric charge eliminated by the charge removal method for 10 charge appearance semiconductor substrates according to claim 40.

ADD A97

SEARCHED INDEXED  
SERIALIZED FILED